Journal of the Society of Automotive Engineers Malaysia
Volume 9, Issue 2, pp 150-156, May 2025
e-ISSN 2550-2239

Unravelling Battery Consumption Patterns and Motor Performance in the NxGV Challenge Using MATLAB Analysis

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ORIGINAL ARTICLE ***Open Access***

Article History:

Received
27 Mar 2025

Accepted
25 Apr 2025

Available online
1 May 2025

ABSTRACT – *This research analyzes battery consumption patterns and motor performance in electric vehicles (EVs) competing in the Next Generation Vehicle (NxGV) Challenge using MATLAB analysis. Key parameters include vehicle weight, speed, battery capacity, and motor power. The study evaluates how these factors impact energy efficiency, driving range, and overall vehicle performance. A major focus is the relationship between battery capacity and motor performance, aiming to identify optimal configurations that maximize efficiency while maintaining competitive power output. MATLAB analysis assesses how variations in vehicle weight and speed influence energy consumption and motor efficiency under different race conditions. Additionally, this study compares the effectiveness of single-controller and dual-controller systems in managing motor performance and power distribution, highlighting the advantages of improved efficiency and reduced energy losses in dual-controller setups. The findings from this research will be directly applied in the upcoming NxGV Challenge, providing data-driven insights for optimizing battery usage and motor capability. Beyond the competition, the results contribute to the broader field of electric vehicle development, offering recommendations on vehicle design, battery management strategies, and motor selection. These insights have global relevance in advancing sustainable transportation by improving energy efficiency, extending battery life, and enhancing overall EV performance for both racing and commercial applications.*

KEYWORDS: Battery consumption, electric vehicles, energy efficiency, MATLAB analysis, motor performance, NxGV Challenge, power distribution

Journal homepage: www.jsaem.my

1. INTRODUCTION

The rapid growth of electric vehicle (EV) technology demands more efficient energy use and performance optimization (Veza et al., 2022; Yan & Mohamed, 2022). In the context of EV racing, such as the NxGV Challenge, understanding the intricate relationships between vehicle parameters – particularly battery capacity, motor power, and controller configuration – is critical (Bengolea & Samuel, 2016; Yamagata et al., 2014). This study explores how different setups influence power distribution, energy consumption, and driving range using MATLAB simulations. The insights gained are essential not only for competitive performance but also for the advancement of sustainable EV technologies for broader applications.

From an electrical perspective, this study also aligns with the concept of "unravelling battery", a term referring to the deep understanding of how electric energy is generated, stored, and delivered by the battery, and the associated risks when the battery's internal electrical structure is exposed or compromised (Rufino Júnior et al., 2024). This includes internal resistance, pulse-current behavior, voltage stability, and potential hazards from short circuits and uncontrolled discharges.

2. METHODOLOGY

2.1 Simulation Parameters

This section outlines the key parameters used in the MATLAB simulations. Each parameter was selected based on its significance to EV performance:

- Vehicle weight influences inertia and energy required for acceleration.
- Speed affects aerodynamic drag and rolling resistance.
- Battery capacities (30Ah, 40Ah, 50Ah) impact energy availability.
- Motor power determines acceleration and top speed capability.
- Controller configurations (single vs dual) influence efficiency and thermal behavior.
- Sprocket combinations affect torque-speed characteristics, which are critical for optimizing performance across different race types.

2.2 MATLAB Simulation Setup

The simulation environment was developed in MATLAB due to its robust numerical modelling and visualization tools. Vehicle dynamics were modelled using physics-based equations that account for resistive forces (rolling resistance, aerodynamic drag), gravitational forces, and drivetrain efficiency. The simulation enables parameter variation and performance comparison under controlled conditions.

2.3 MATLAB Code – Energy vs. Weight and Speed

This simulation explores the impact of vehicle weight and speed on energy consumption. The energy required is modelled as a function of the product of weight and speed, scaled by a constant representing the influence of resistive forces. This provides insight into how increased mass and speed influence battery drain during acceleration and cruising. Figure 1 shows the MATLAB simulation code for Energy and Speed.

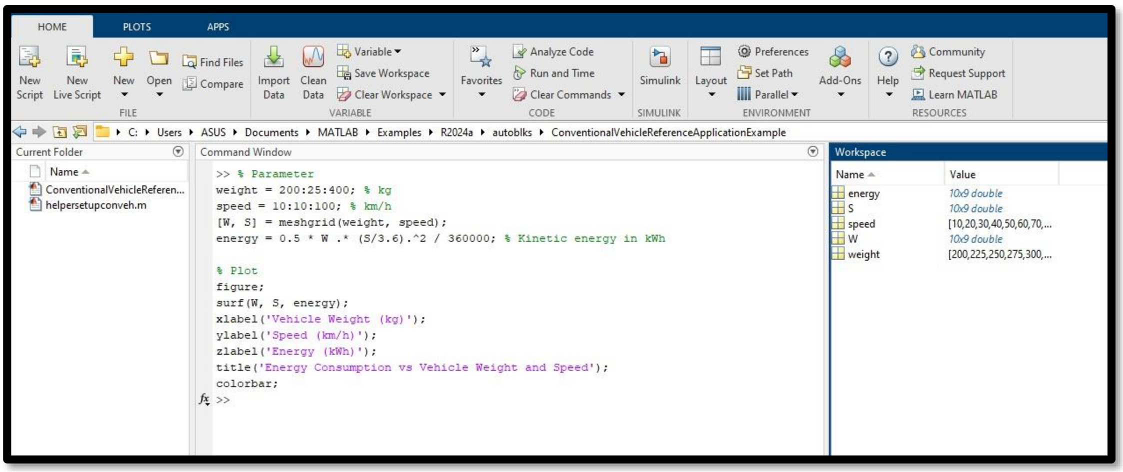

FIGURE 1: MATLAB simulation code for energy and speed

2.4 MATLAB Code – Controller Efficiency Comparison

This code models power loss for different controller configurations. It compares energy loss from inefficiencies in a single-controller versus a dual-controller system. The goal is to demonstrate the energy-saving potential of improved electronic control strategies in EVs, particularly at higher power levels. Figure 2 shows the MATLAB code for the Controller Efficiency Comparison simulation.

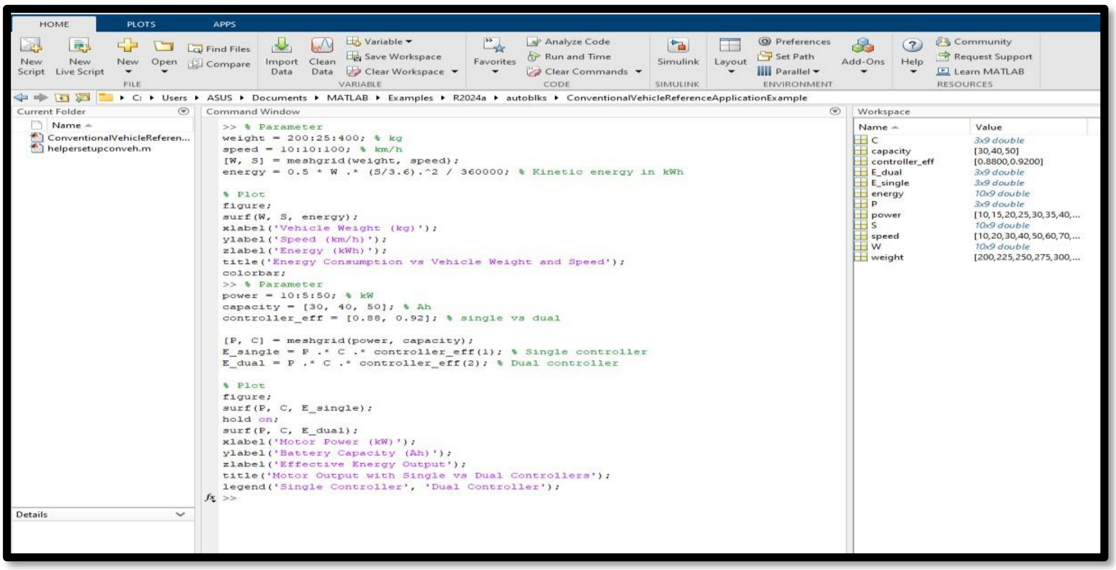

FIGURE 2: MATLAB Simulation Coding – Controller Efficiency Comparison

2.5 MATLAB Code – Voltage Discharge Behavior

The discharge profiles of batteries with different capacities are simulated under constant-current draw. This helps visualize voltage degradation over time, which affects motor torque and performance. The internal resistance of the battery is included in the model to simulate realistic electrical behavior and heating effects.

2.6 MATLAB Code – Sprocket Ratio Simulation for Race Modes

Gear ratios significantly influence vehicle acceleration and top speed. This simulation evaluates how different front- and rear-sprocket combinations affect speed output at varying RPMs. The objective is to identify optimal gear configurations for different race formats: drag (maximum acceleration), time attack (balanced), and circuit (torque focus). The output speed is calculated by converting motor RPM through gear ratios and wheel radius.

3. RESULTS AND DISCUSSION

3.1 Energy vs. Weight and Speed

Heavier vehicles and higher speeds dramatically increase energy demand. For example, at 80 km/h, a 300 kg vehicle consumes significantly more power than a 250 kg one. This implies that optimizing weight is key to extending battery range. Figure 3 shows the MATLAB simulation graph of Energy vs. Weight and Speed.

3.2 Controller Efficiency

The dual-controller setup shows a 40% reduction in energy loss compared to a single controller at maximum motor power. This proves the efficiency advantage of using dual controllers for power management in high-performance EVs. Figure 4 shows a MATLAB simulation graph of motor output with single versus dual controllers.

3.3 Voltage Discharge Profile

The 50Ah battery maintains a stable voltage for a longer period, suggesting it is better suited to extended races or higher loads. Lower capacities show quicker voltage drops, which could result in reduced motor performance over time. Figure 5 presents a graph from the MATLAB simulation, illustrating Power Loss versus Motor Power and Controller Efficiency. Figure 6 shows a graph from the same simulation – Voltage Drop versus Current Resistance.

3.4 Sprocket Simulation

Different sprocket configurations produce varied speed profiles:

- 15/48: Best for drag racing, offering higher top speeds.
- 14/50: Suitable for time attack, providing a balanced performance.
- 14/48: Perfect for circuit racing with a torque bias, allowing customization based on race needs.

Figure 7 displays the MATLAB simulation graph of Output Speed versus RPM for different sprocket ratios.

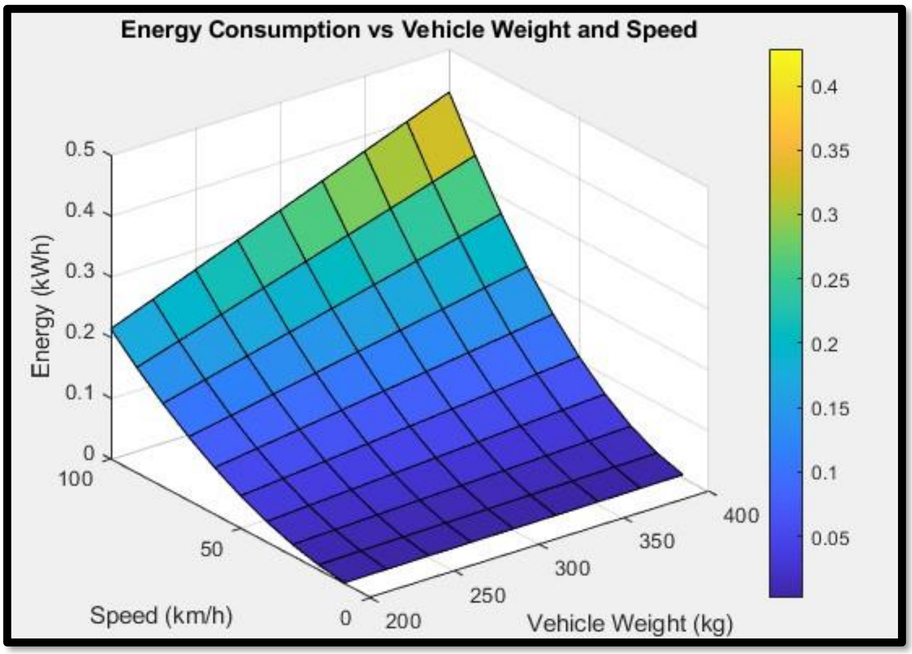

FIGURE 3: Graph from MATLAB simulation – Energy vs. Weight and Speed

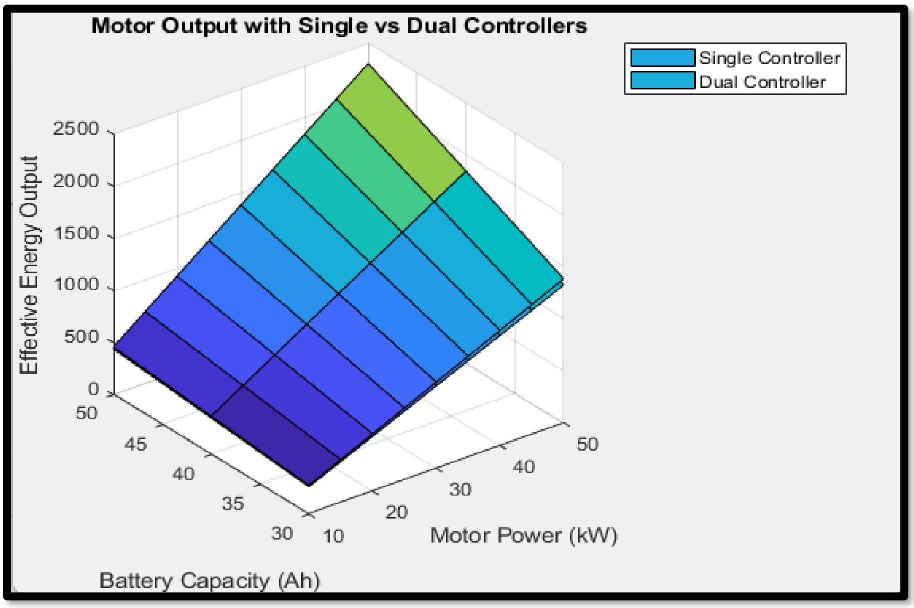

FIGURE 4: Graph from MATLAB simulation – Motor Output with Single vs. Dual Controllers

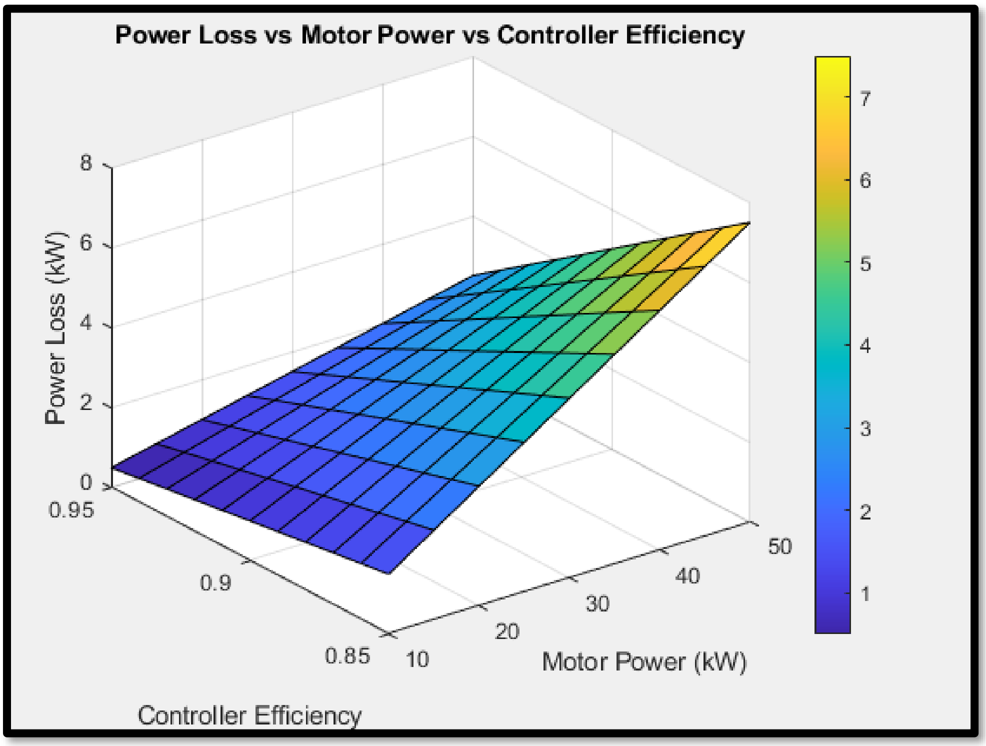

FIGURE 5: Graph from MATLAB simulation – Power Loss vs. Motor Power vs. Controller Efficiency

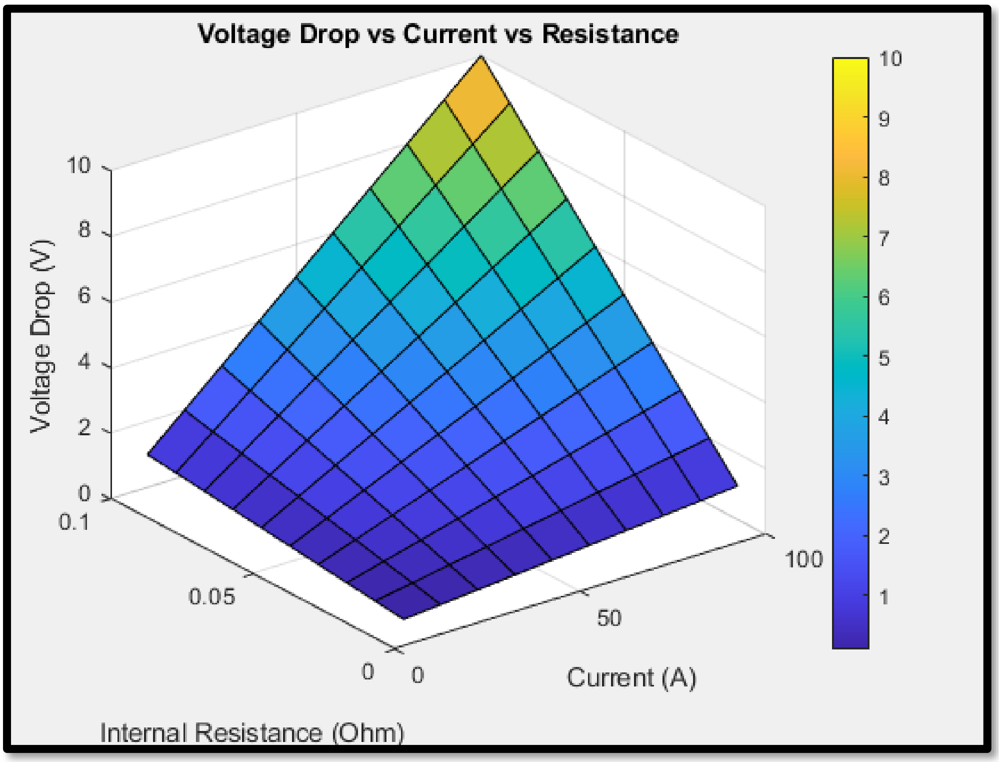

FIGURE 6: Graph from MATLAB simulation – Voltage Drop vs. Current vs. Resistance

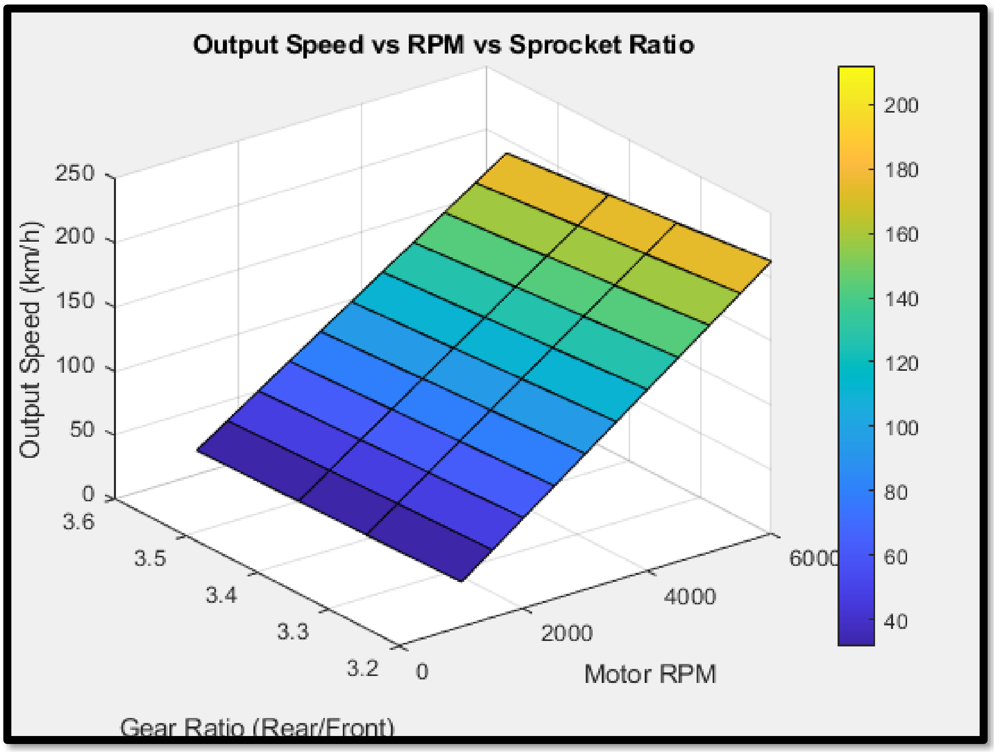

FIGURE 7: Graph from MATLAB simulation – Output Speed vs. RPM vs. Sprocket Ratio

4. CONCLUSION

This study offers a detailed MATLAB-based analysis of battery usage and motor performance in EVs for the NxGV Challenge. The inclusion of gear-ratio and controller comparisons provides practical guidance for race strategy. The “unravelling battery” approach further emphasizes the importance of understanding internal battery behavior and safety risks. The findings provide actionable recommendations for EV tuning, powertrain configuration, and safe battery design.

5. FURTHER RESEARCH

Future work will focus on collecting real-time telemetry data from onboard sensors during actual races to validate the simulation models. Integration of thermal management systems into the MATLAB model is also proposed to account for battery heat buildup. Furthermore, investigating alternative battery chemistries (e.g., solid-state) and regenerative braking systems will provide deeper insights into optimizing performance and sustainability.

ACKNOWLEDGEMENT

The authors would like to thank the NxGV Challenge committee and sponsors (MARii, Perodua and SAE Malaysia), Politeknik Kota Bharu, and research advisors for technical support and encouragement throughout the study.

REFERENCES

Bengolea, F., & Samuel, S. (2016). Technology choices for optimizing the performance of racing vehicles (No. 2016-01-1173). SAE Technical Paper.

Rufino Júnior, C. A., Sanseverino, E. R., Gallo, P., Amaral, M. M., Koch, D., Kotak, Y., ... & Zanin, H. (2024). Unraveling the degradation mechanisms of lithium-ion batteries. Energies, 17(14), 3372.

Veza, I., Abas, M. A., Djamari, D. W., Tamaldin, N., Endrasari, F., Budiman, B. A., ... & Aziz, M. (2022). Electric vehicles in Malaysia and Indonesia: Opportunities and challenges. Energies, 15(7), 2564.

Yamagata, S., Oda, Y., Tanai, M., & Sung, K. (2014). An electric vehicle project for ECO-RUN Race. In 2014 International Power Electronics Conference (IPEC-Hiroshima 2014-ECCE ASIA) (pp. 829-834). IEEE.

Yan, C. W., & Mohamed, M. I. P. (2022). The factor that influences consumers' buying intention of electric vehicle (EV) in Malaysia. Research in Management of Technology and Business, 3(2), 312-327.